



Metal	Removal of		Polishing	Stripping
	Heavy Oxides	Light Oxides & General Cleaning		
I Copper	NH <sub>4</sub> Cl + HCl (IA)	H <sub>2</sub> CrO <sub>4</sub> (IB)	HNO <sub>3</sub> + HCl + H <sub>2</sub> SO <sub>4</sub> (IC) HNO <sub>3</sub> + H <sub>2</sub> SO <sub>4</sub> + HCl (ICA) H <sub>3</sub> PO <sub>4</sub> + H <sub>2</sub> SO <sub>4</sub> (9:1) (ICb)	H <sub>2</sub> SO <sub>4</sub> + CrO <sub>3</sub> (ID) NH <sub>4</sub> OH + (NH <sub>4</sub> ) <sub>2</sub> S <sub>2</sub> O <sub>8</sub> (IDA)
II Moly	HNO <sub>3</sub> + H <sub>2</sub> CrO <sub>4</sub> (IIA) § Na <sub>2</sub> CO <sub>3</sub> (IIAa)	HNO <sub>3</sub> + H <sub>2</sub> CrO <sub>4</sub> (IIA) § Na <sub>2</sub> CO <sub>3</sub> (IIAa)	H <sub>2</sub> SO <sub>4</sub> (IIB)	
III Nickel	HCl (IIIA)	HCl (IIIA)	H <sub>2</sub> SO <sub>4</sub> (IIIB)	HNO <sub>3</sub> + HCl (IIIC)
IV Tantalum	H <sub>2</sub> F <sub>2</sub> + HNO <sub>3</sub> (IVA)	H <sub>2</sub> F <sub>2</sub> + HNO <sub>3</sub> (IVA)		
V Tungsten	Na <sub>2</sub> O <sub>2</sub> (VA) Na <sub>2</sub> CO <sub>3</sub> (VAa)	K <sub>3</sub> Fe(CN) <sub>6</sub> + KOH (VB) (VB)	Na <sub>2</sub> CO <sub>3</sub> + NaCl (VC)	
VI Steel	H <sub>2</sub> SO <sub>4</sub> (VIA) HCl + CH <sub>3</sub> COOH (VIAa)		H <sub>3</sub> PO <sub>4</sub> + H <sub>2</sub> SO <sub>4</sub> (3:2) (VIB)	
VII Kovar	HCl (VIIA) HCl + HNO <sub>3</sub> (VIIAa)		H <sub>2</sub> SO <sub>4</sub> (VIIB) H <sub>3</sub> PO <sub>4</sub> + H <sub>2</sub> SO <sub>4</sub> (3:2) (VIIBa)	
VIII Cadmium				NH <sub>4</sub> NO <sub>3</sub> (VIII A)
IX Silver				HNO <sub>3</sub> + H <sub>2</sub> SO <sub>4</sub> (IX A)

§ HNO<sub>3</sub> & H<sub>2</sub>CrO<sub>4</sub> for Moly Grids

\* Revised Schedule Numbers

24-498-15-60

118/bw



SUBJECT METAL CLEANING SCHEDULES  
Process Specifications

SUPERSEDED DATE 6/22/49

GUIDE TO METAL CLEANING

I. COPPER (Cu)

A. Removal of heavy oxide (applicable to air fired parts and after glassing operations) - Ammonium Chloride Dip.

1. Solution (totaling 1000 cc.)
  - 225 grams Ammonium Chloride (NH<sub>4</sub>Cl)
  - 225 cc. conc. Hydrochloric Acid (HCl)
  - 550 cc. water.

HYDROCHLORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

\*\* DANGER

B. Removal of light oxide - Chromic Acid Dip.

1. For bright finish, or resistance against further oxidation use standard Chromic Acid (H<sub>2</sub>CrO<sub>4</sub>) Dip:

- a. Solution (totaling 1400 cc.)
  - 13 cc. conc. Sulfuric Acid (H<sub>2</sub>SO<sub>4</sub>)
  - 2-1/2 lb. Chromic Acid Flake (CrO<sub>3</sub>)
  - 1000 cc. water

CHROMIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7B

\*\*SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

→ DANGER

- b. Time: 1/2 to 1 minute.
- c. Temperature: Room.

C. Cleaning prior to metal-glass sealing operations - Bright Dip.

1. Bright Dip "A" Solution
  - 300 cc. conc. Nitric Acid (HNO<sub>3</sub>)
  - 1 cc. Hydrochloric Acid (HCl)
  - 300 cc. conc. Sulfuric Acid (H<sub>2</sub>SO<sub>4</sub>)
  - 450 cc. water

NITRIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

HYDROCHLORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

\*\* DANGER

2. Time: 1 to 2 seconds.
3. Temperature: Room.

Ca. For a brighter finish use the following Bright Dip.

1. Bright Dip "B" Solution.
  - 380 cc. conc. Nitric Acid (HNO<sub>3</sub>)
  - 760 cc. conc. Sulfuric Acid (H<sub>2</sub>SO<sub>4</sub>)
  - 3 cc. conc. Hydrochloric Acid (HCl)
  - 95 cc. water

NITRIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

HYDROCHLORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

\*\* DANGER

2. Temperature: Room or below.



GUIDE TO METAL CLEANING

I. COPPER (Cu) Cont'd.

Cb. For bright new finish clean electrolytically:

1. Solution

- 900 cc. Phosphoric Acid ( $H_3PO_4$ )
- 100 cc. Sulfuric Acid ( $H_2SO_4$ )
- 25 cc. water.

\*\* DANGER

PHOSPHORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C  
SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

2. Electropolish using lead cathode, current density 1-10 amps/sq. in.

D. Stripping copper plate (not for use in presence of silver)

1. Solution (approx. 1440 cc. total)

- 50 cc. Sulfuric Acid ( $H_2SO_4$ )
- 2-1/2 lbs. Chromic Acid Flake ( $CrO_3$ )
- 1000 cc. water.

\*\* DANGER

CHROMIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7B  
SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

NOTE: Will not attack nickel, iron, or kovar.

Da. Stripping (for minute quantities of copper impurities or welding splash)

1. Solution

- 250 cc. Ammonium Hydroxide ( $NH_4OH$ )
- 500 cc. water.
- 1/4 teaspoonfull Ammonium Persulfate ( $(NH_4)_2S_2O_8$ ) crystals (add intermittently - every half hour).

DANGER

AMMONIUM HYDROXIDE HANDLING PRECAUTIONS: See S.N. 33-2-8A

- 2. Time: Until copper is removed - will vary with thickness of copper film.
- 3. Temperature: Room

II. MOLYBDENUM (Mo)

A. Removal of heavy and light oxides - cleaning moly or platinum clad moly grids to reduce grid emission.

- 1. Nitric Acid ( $HNO_3$ ) Dip.
- 50%  $HNO_3$  solution.

\*\* DANGER

NITRIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

- Time: 1 minute.
- Temperature: Room

2. Cold Tap Water Rinse

IMPORTANT: Hot water would oxidize moly.

(Cont. on next page)

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GUIDE TO METAL CLEANING

II. MOLYBDENUM (Mo) Cont.

A. (Continued)

3. Standard Chromic Acid ( $H_2CrO_4$ ) Dip

Standard  $H_2CrO_4$  solution - see item IB

DANGER

CHROMIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7B

Time: 1 minute

Temperature: Room

4. Tap water rinse followed by distilled water

Aa. Electro-Chemical

1. Sodium Carbonate ( $Na_2CO_3$ ) solution (250 g/liter)

DANGER

SODIUM CARBONATE HANDLING PRECAUTIONS: See S.N. 33-2-8A

2. 20-100V A.C. supply (usual operating range 40-60V - limited by local effects such as arcing).

3. Temperature: 40° C. max.

B. Electropolish

1. 50% Sulfuric Acid ( $H_2SO_4$ ) solution.

\*\* DANGER

SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

2. D.C. Power Supply

Work is anodic (+ terminal)

Lead cathode (see directions for electropolishing)

III. NICKEL (Ni)

A. Removal of light oxide.

1. 50% Hydrochloric Acid (HCl) solution

\*\* DANGER

HYDROCHLORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

2. Temperature: Boiling.

B. Electro-polishing (similar to that for Moly - see item IIA above)

1. 50% Sulfuric Acid ( $H_2SO_4$ ) solution.

\*\* DANGER

SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

2. Temperature: 40° C. max.



SUBJECT METAL CLEANING SCHEDULES  
Process Specifications

SUPERSEDED DATE 2/27/48

GUIDE TO METAL CLEANING

III. NICKEL (Ni) Cont'd.

C. Stripping Nickel from Steel or Kovar.

1. Solution

- 99% Nitric Acid (HNO<sub>3</sub>)
- 1% Hydrochloric Acid (HCl)

NITRIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

\*\* DANGER

HYDROCHLORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

2. Time: Until action ceases.

NOTE: If used for Nickel plate, container and parts must be perfectly dry, for if water is kept out, the solution will remove Nickel without attacking steel or kovar.

IV. TANTALUM (Ta)

A. Removal of heavy and light oxide.

- 1. Rapid etching solution (Laboratory procedure only, NOT for factory use)  
90% Hydrofluoric Acid (H<sub>2</sub>F<sub>2</sub>), plus a few drops of Nitric Acid (HNO<sub>3</sub>).

HYDROFLUORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7A.

→ DANGER

\*\*NITRIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

2. Time: 15-45 seconds.

3. Temperature: Room.

V. TUNGSTEN (W)

A. Removal of heavy oxide with Sodium Peroxide (Na<sub>2</sub>O<sub>2</sub>)

- 1. Solution of 1/4 - 1/2 lb. Na<sub>2</sub>O<sub>2</sub>/liter.

SODIUM PEROXIDE HANDLING PRECAUTIONS: See S.N. 33-2-8A

DANGER

Cover parts with water, and add Na<sub>2</sub>O<sub>2</sub> intermittently.  
Change solution with every batch.

2. Temperature: Boiling.

Aa. Electro-Chemical (like Moly Cleaning item IIAa).

- 1. Sodium Carbonate (Na<sub>2</sub>CO<sub>3</sub>) solution (250 g/liter)

SODIUM CARBONATE HANDLING PRECAUTIONS: See S.N. 33-2-8A.

DANGER

2. A.C. voltage supply

3. Temperature: 40° C. max.



SUBJECT METAL CLEANING SCHEDULES  
 Process Specifications

SUPERSEDED DATE 2/25/48

GUIDE TO METAL CLEANING

V. TUNGSTEN (W) Cont.

B. Removal of light oxide

1. Solution

12.5% (by wt.) Potassium Ferricyanide ( $K_3Fe(CN)_6$ )

12.5% (by wt.) Potassium Hydroxide (KOH)

NOTE: Use unadvisable due to dangers of deadly Hydrocyanide Acid (HCN) gas.

**DANGER**

CYANIDE HANDLING PRECAUTIONS: See S.N. 33-2-13A

POTASSIUM HYDROXIDE HANDLING PRECAUTIONS: See S.N. 33-2-8A

C. Electro-polish.

1. A polished surface is obtained if a trace of Sodium Chloride (NaCl) is added to the  $Na_2CO_3$  electrolytic bath described in items IIAa and VAa.

VI. STEEL

A. Removal of heavy oxide.

1. 50% Sulfuric Acid ( $H_2SO_4$ ) solution.

\*\* **DANGER**

SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

2. Temperature: 50° - 70° C.

Aa. Alternate

1. 10-25% Hydrochloric Acid (HCl) + 2-3% Acetic Acid ( $CH_3COOH$ )

\*\* **DANGER**

HYDROCHLORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

ACETIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

2. Temperature: Not above 50° C.

B. Electro-polishing.

1. Solution

600 cc. Phosphoric Acid ( $H_3PO_4$ )

400 cc. Sulfuric Acid ( $H_2SO_4$ )

\*\* **DANGER**

PHOSPHORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

2. Temperature: Not to exceed 50° C. Water cool bath.

3. Current Density: 5-40 amps/sq. in.

NOTE: Always use 1/2% Morpholine in final water rinse for steel to act as a rust inhibitor.

\*\* **DANGER**

MORPHOLINE HANDLING PRECAUTIONS: See S.N. 33-2-8A.



SUBJECT METAL CLEANING SCHEDULES  
 Process Specifications

SUPERSEDED DATE

GUIDE TO METAL CLEANING

VII. KOVAR (Co-Ni-Fe)

A. Removal of heavy oxide

1. 50% Hydrochloric Acid (HCl)

\*\* DANGER

HYDROCHLORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

2. Time: 1-3 minutes; repeat if necessary.
3. Temperature: Boiling.

Aa. Cleaning preparatory to glassing.

1. Solution

100 parts Hydrochloric Acid (HCl).  
 100 parts water - see W621.  
 5 parts Nitric Acid (HNO<sub>3</sub>)

\*\* DANGER

HYDROCHLORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.  
NITRIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C

2. Temperature: 60-80° C.

NOTE: To increase rate of reaction more HNO<sub>3</sub> may be used.  
 Solution.

50 cc. water.  
 50 cc. Hydrochloric Acid (HCl)  
 5 cc. Nitric Acid (HNO<sub>3</sub>)

B. Electropolish

1. 50% Sulfuric Acid (H<sub>2</sub>SO<sub>4</sub>)

\*\* DANGER

SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

2. Temperature: Room. Water cool bath.

Ba. Alternate (Same as electropolishing steel - see item VIB.)

1. Solution

600 cc. Phosphoric Acid (H<sub>3</sub>PO<sub>4</sub>)  
 400 cc. Sulfuric Acid (H<sub>2</sub>SO<sub>4</sub>)

\*\* DANGER

PHOSPHORIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.  
SULFURIC ACID HANDLING PRECAUTIONS: See S. N. 33-2-7C.

2. Temperature: Not to exceed 50° C. Water cool bath.
3. Current Density: 5-40 amps/sq. in.

NOTE: Rate of reaction increased with increase in H<sub>2</sub>SO<sub>4</sub> concentration.  
 Always use 1/2% Morpholine in final water rinse for steel to act  
 as a rust inhibitor.

\*\* DANGER

MORPHOLINE HANDLING PRECAUTIONS: See S.N. 33-2-8A

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☆ CHANGE  
 ☆☆ ADDITION  
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SUBJECT METAL CLEANING SCHEDULES  
 Process Specifications

SUPERSEDED DATE

GUIDE TO METAL CLEANING

VIII. CADMIUM (Cd)

A. Stripping

1. Solution Ammonium Nitrate ( $NH_4NO_3$ ) (1 lb./gal. water).

2. Time: 15-20 minutes.

IX. SILVER (Ag)

A. Stripping

1. Solution of Nitric ( $HNO_3$ ) and Sulfuric ( $H_2SO_4$ ) Acids in ratio of 1:19.

NITRIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

SULFURIC ACID HANDLING PRECAUTIONS: See S.N. 33-2-7C.

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DANGER

2. Time: 1/2 to 4 hours, or until parts turn black.

3. Temperature: 60-90° C.

ALTERNATIVE: Parts may be left in solution overnight at room temperature.

IMPORTANT: Parts must be dry - no water present.

ENGINEERING SECTION  
 STANDARDIZING

1-498-17-62 PCL11564-118/bw

☆ CHANGE  
 ☆☆ ADDITION  
 ☆☆☆ DELETION

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